October 7, 2019

***By ECFS***

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

**Re: Expanding Flexible Use of the 3.7 to 4.2 GHz Band, GN Docket No. 18-122**

Dear Ms. Dortch:

On October 3, 2019, Ross J. Lieberman, ACA Connects – America's Communications Association ("ACA Connects"); Alexi Maltas, Competitive Carriers Association ("CCA"); Elizabeth Andrion and Colleen King, Charter Communications, Inc. ("Charter"); and Howard Symons of Jenner & Block LLP, counsel to Charter, met with Aaron Goldberger, Legal Advisor, Wireless and International to Chairman Ajit Pai, regarding the above-referenced proceeding.

During the meeting, this coalition of competitive and rural cable and wireless companies presented and discussed the enclosed supplement to the 5G Plus Plan.[1] The supplement provides further details on how to design and implement a fiber network for delivery of multichannel video that matches or exceeds the reliability, capacity and quality provided today via the 3.7-4.2 GHz spectrum band ("C-Band"). To ensure that the network meets the requirements of video programmers, the supplement proposes the allocation of an additional $0.8 billion for programmers' transition costs. The supplement also clarifies and enhances other aspects of the 5G Plus Plan, including safeguards for incumbent C-Band users, protections for the U.S. taxpayer, and an important role for the transition administrator in ensuring a timely transition.

[1] *See* Letter From Pantelis Michalopoulos to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed July 9, 2019); Letter from Ross Lieberman, ACA Connects – America's Communications Association, Alexi Maltas, Competitive Carriers Association, and Elizabeth Andrion, Charter Communications, Inc., to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (July 2, 2019).

The coalition also underscored the immense benefits of the 5G Plus Plan and its advantages over alternative approaches. The 5G Plus Plan would clear 370 megahertz of C-Band spectrum for 5G at a rapid pace, future-proof the distribution of multichannel video, finance fiber buildout in rural communities, usher in a better and cheaper video distribution medium than the C-Band, and protect incumbents, all while bringing in billions of dollars for the U.S. Treasury. No other plan on record comes close to matching these benefits.

Respectfully submitted,

/s/

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cc (via email): Aaron Goldberger

# 5G Plus Plan Supplement

September 23, 2019

**Prepared for:** ACA AMERICA'S COMMUNICATIONS ASSOCIATION #ACAConnects

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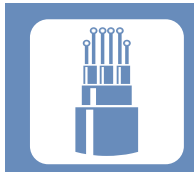
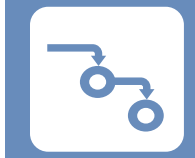
# 5G Plus Plan Supplement Overview

ACA Connects has supplemented the 5G Plus Plan to provide more details about the fiber network that will be used by the MVPD industry, the transition to this network, and other changes to protect the public interest



**Fiber Network Improvements**
Amendments ensure fiber network will match or exceed the reliability, capability and quality of C-band distribution

**More Funding for Programmers' Reimbursements**
Amendments add $0.8B to cover programmers' capital expenditures and 5-year operating expenses



**Better Taxpayer Protections**
Amendments ensure U.S. Treasury receives at least a minimum return on auction proceeds, and satellite industry receives no more than a maximum amount in incentive payments

**Measures to Safeguard C-band Users**
Amendments ensure satellite industry supports C-band customers during and after transition

**Other Supplements**
Amendments clarify management role of transition facilitator and transition clearing timeline

Source: Cartesian, ACA Connects





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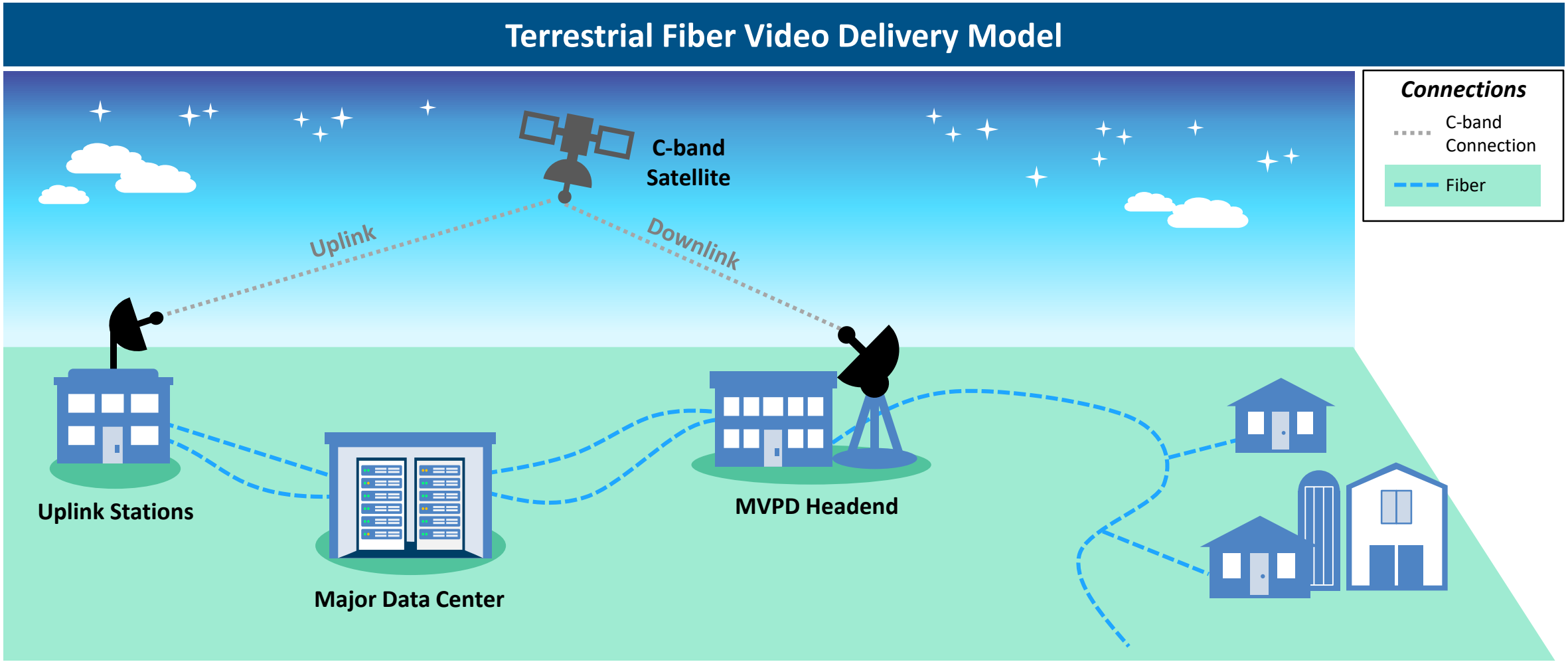
# 5G Plus Plan Delivery Model

The 5G Plus Plan proposed to clear at least 370 MHz of C-band spectrum in a timely manner by transitioning the delivery of MVPD programming from the C-band to a fiber network




Source: Cartesian, ACA Connects

# Amendment Process

ACA Connects has spent several weeks discussing details of the plan with various parties, such as major programmers, who will be affected or play a part in the proposed transition

- Over 20 hours in separate meetings with over **10 programming companies** of different sizes
- Two webinars with Q&A sessions, attended by dozens of programmers
- Meetings with multiple national fiber service providers
- Meetings with content aggregators

**Feedback:** We heard concerns and incorporated feedback from all parties to provide assurances of reliability, capability, quality and cost for the transition to a fiber network.

Source: Cartesian, ACA Connects

# Amendments to Original 5G Plus Plan

| | | |
|---|---|---|
| Programmer Network | Managed Video Transport Services | Four nationwide fiber infrastructure providers will deploy a video transport network across 42 data centers to programmer specifications |
| | Programmer Autonomy/Optionality | Programmers will receive funds to make key decisions regarding network architecture – contract services to vendors of choice |
| | Fiber Reliability & Capacity | Refinements including route diversity (200 ft minimum separation distance), and upgraded backbone capacity (100G) |
| | Managed Video Transport Network | Traffic rides over network deployed solely for the purpose of video transport |
| | Necessary Contractual Changes | MVPDs will agree to programming contract changes necessary for the transition to a fiber network, while leaving other provisions unchanged |
| | Backup/Disaster Recovery Sites | Increase in the number of uplink sites to reflect the number of programmers' existing backup/disaster recovery sites |
| | Security & Network Operations Staff | Security system supporting end-to-end encoding and responsible for 24/7 operations of the new private network |
| Other | Taxpayer Protections | U.S. Treasury receives minimum return on auction proceeds, and satellite industry does not obtain windfall |
| | C-band User Protections | Satellite industry to receive incentive payments over seven-year period to ensure C-band users receive good service during and after transition |
| | Transition Facilitator | Responsibilities of the transition facilitator better defined |
| | Timeline Clarification | Market clearing timelines start from date transition facilitator receives reimbursement funds from winning bidders – planning can begin immediately |

**Programmer Reimbursement**

Changes increased reimbursable funds to programmers to approximately

**$1B**

Source: Cartesian, ACA Connects





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# Benefits of a Comprehensive Transition to Fiber Video Transport

Fiber-based video transport offers a future-proof, superior delivery mechanism at a lower steady-state cost

| Fiber-based Video Transport Provides More for Less | | |
|---|---|---|
| 1 | **Operational Cost Reduction** | • Fiber-based video distribution steady-state costs are significantly lower than satellite video distribution costs, even under the use of new compression standards (HEVC) |
| 2 | **Improved Customer Experience** | • Fiber video distribution allows for improved bandwidth, better quality of service (QoS) and lower latency<br>• Improves customer experience and can support rapid growth in use cases with higher video resolution and bandwidth (e.g., Ultra-HD, Virtual Reality, etc.) |
| 3 | **More Network Capacity** | • Fiber has practically unlimited bandwidth (e.g., about 100 wavelengths x 100Gbps can be transmitted over 1 fiber pair) compared to the finite bandwidth of C-band<br>• Current & near-future needs satisfied; no need for a forced migration to next generation compression standard |
| 4 | **No Interference** | • Fiber transmission offers an isolated glass medium with no external interferences<br>• C-band is a shared wireless transmission medium and signal transmission is susceptible to both in-band and out-of-band interference, including from 5G |
| 5 | **Increased Regulatory Certainty** | • The 5G Plus Plan provides a comprehensive transition that eliminates the uncertainty of future spectrum repurposing associated with plans that keep video programming on the C-band |

Source: Cartesian, ACA Connects





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# 5G Plus Plan's Approach

Programmers' concerns, interests, and desires dictated our plan's approach

- **Programmers' Content must be Transported Over Private Video Transport Network Dedicated Solely For This Purpose**
- **Reliability, Capability, and Quality of Fiber Network must Match or Exceed C-band Delivery**
- **Programmers must have Autonomy/Optionality to Choose Vendors, Equipment, and Software for the Fiber Networks of their Choice**
- **Programmers must have Competitive Options for Managed Video Transport Services & Fiber Connectivity**
- **Fiber Connectivity must be Provided to all Locations Receiving MVPD Programming via C-band, Including any Non-MVPD locations**
- **Cable Operators must be willing to Update Certain Terms in their Programming Contracts to be Consistent with the use of the Fiber Network**
- **MVPDs should not be Forced to Forgo Use of C-band Earth Stations in a Market Until All MVPDs in that Market Are Connected to Fiber**
- **Programmers should not be Left Paying for Fiber Delivery for Some MVPDs and Satellite Delivery for Other MVPDs**
- **All Cost Related to Fiber Delivery Must Be Reimbursed – 5G Auction Winners Must Provide 130% of Estimated Cost to Account for Overruns**

**We have executed on each of these matters while designing the 5G Plus Plan**

Source: Cartesian, ACA Connects





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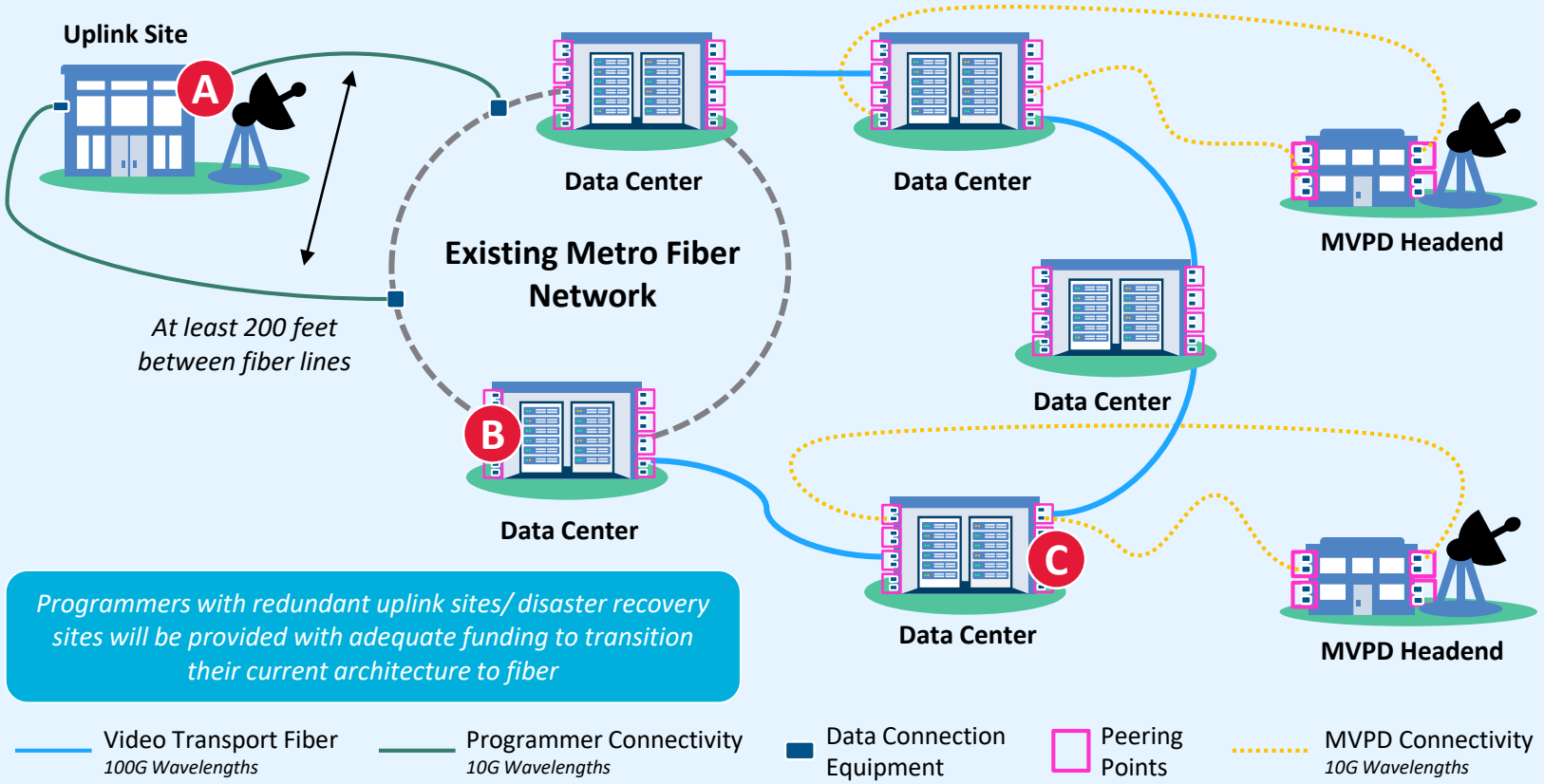
# Video Transport Network – Architecture

The 5G Plus Plan reimburses programmers for the use of a video transport network

## 5G Plus Plan Terrestrial Video Delivery Network Architecture




**A Programmer Connectivity**

Programmers will transport their content from their uplink site(s) to two nearby handoff points

**B Managed Video Transport Service**

Programmers will be given funds to pay MVTPs for a managed network solution to transport content from each programmer's two handoff points to the 42 data centers

**C MVPD Handoff**

MVPDs will be responsible for obtaining connectivity to a data center, where they will cross-connect with the programmers' MVTPs

Source: Cartesian, ACA Connects

# Video Transport Network – Five 9s of Reliability

The video transport network's architecture is designed to provide at least 99.999% reliability

## 5G Plus Plan Terrestrial Video Delivery Architecture

***Programmer Reimbursement Covers:***

**Redundant Fiber**

The fiber network has been designed to provide redundant and geographically diverse fiber routes of at least 200 feet as they travel from all existing uplink sites to two different handoff points, and to enter and exit each facility from opposite sides

**Redundant Equipment**

The fiber network has been designed to include redundant equipment, to ensure full redundancy end-to-end

**Network Operations Center**

The fiber network will have a network operations center that is equipped with traffic monitoring software and a team of 340 engineers, client support, and technicians available for immediate issue resolution

***SEE SLIDE 19***

**Based on its own reports, the satellite industry only provides between three and four '9s' of reliability** ***SEE SLIDE 20***

Source: Cartesian, ACA Connects

# 5G Plus Plan Video Transport Solution

The proposed fiber network contains all components required for reliable, secure video transport and handoff via fiber

## A Uplink Site to MVTP

### Uplink Site Connectivity

- Redundant 10G wavelengths
- Two geographically diverse routes, at least 200 feet apart, to two hand-off points

### Uplink Site Equipment & Software

- New Enterprise Customer Premises Equipment (CPE) to enable fiber connectivity
- If upgrades for IP transport are required:
  - Encryption
  - Encoding
- Installation, testing and turn-up of new equipment and software

***SEE SLIDES 21-22***

## B Managed Video Transport Provider

### Data Center Connectivity

- 100G backbone connectivity among the 42 data centers
- Dual geographically diverse circuits; entering data center from different directions (east/west); at least 200 feet apart
- Redundant optical transmission, routing and aggregation switching equipment
- Cross-connects for programmers to the video transport network in data centers
- New User Interface for programmable access

### Dedicated Network Operations Center

- 24/7 dedicated NOC teams for end-to-end network monitoring

### Other Software & Security

- Any necessary development of a third-party security solution

***SEE SLIDES 23-24, 35***

## C MVPD Hand-off

### Data Center Hand-off

- Cross-connects enable MVPDs to access all programmer content

### MVPD Headend

- New IP integrated receivers/decoders (IRDs)
  - Maintained flexibility for different levels of channel density per IRD
- If necessary, the MVPD is reimbursed to obtain MPEG-2 transcoders/analog conversion equipment at its headend

*MVPDs will be reimbursed separately for establishing (either through IRU or build) fiber connectivity to their nearest data center(s)*

***SEE SLIDE 24***

Source: Cartesian, ACA Connects





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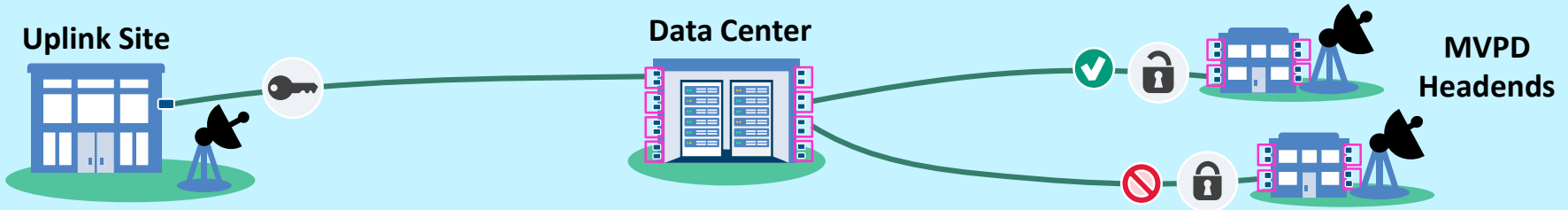
# Security & Network Operations

Programmers will maintain controlled access through the endpoints while a dedicated NOC team by the managed video transport providers will guarantee 24/7 operational excellence

## Programmable Access & Security

**Encoding of Content** → **Encrypted Video Transport** → **Decoding of Content**




Programmers maintain end-to-end control over encryption and where content is directed through an API

*SEE SLIDE 22*

## Network Operations

| | |
|---|---|
| **Network Operation Center Team** | A team of engineers, client support and data techs at each data center resolve issues as they arise |
| **Network Management System** | Network probes automatically monitor traffic at data centers and MVPDs |
| **Network Probe Monitoring Process** | NOC team technicians resolve the issue and report to client |

*SEE SLIDE 23*

Source: Cartesian, ACA Connects





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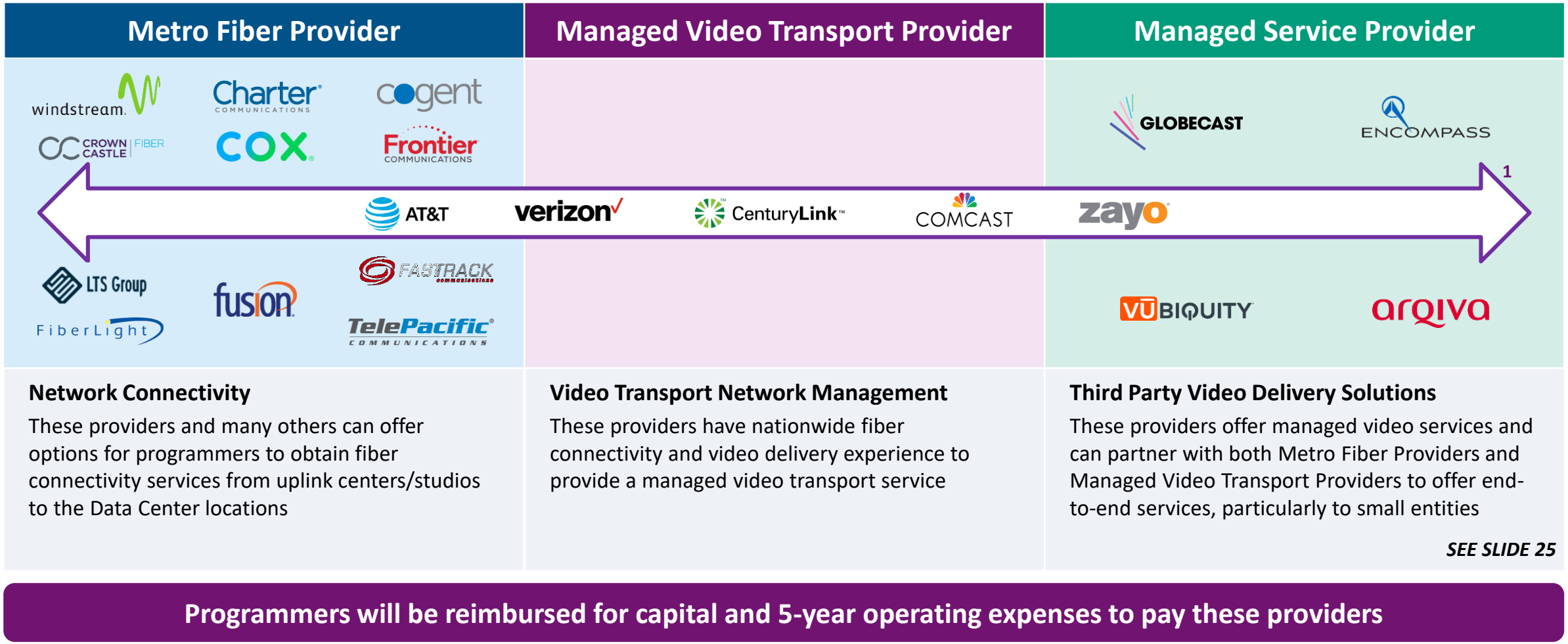
# Service Provider Options

Programmers can choose among an existing ecosystem of fiber-based video solution providers




**Network Connectivity**

These providers and many others can offer options for programmers to obtain fiber connectivity services from uplink centers/studios to the Data Center locations

**Video Transport Network Management**

These providers have nationwide fiber connectivity and video delivery experience to provide a managed video transport service

**Third Party Video Delivery Solutions**

These providers offer managed video services and can partner with both Metro Fiber Providers and Managed Video Transport Providers to offer end-to-end services, particularly to small entities

***SEE SLIDE 25***

**Programmers will be reimbursed for capital and 5-year operating expenses to pay these providers**

1. These managed video transport providers could provide programmers with both metro fiber connectivity and a managed video transport service, offering an end-to-end solution
Note: Inclusive but not an exhaustive list of companies
Note: Use of logos does not imply support of the 5G Plus Plan
Sources: Cartesian, Communication Provider websites





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# Future State Comparison: Fiber vs. Satellite Cost per Channel

Fiber delivery per channel is estimated at **70% to 83%** less than satellite delivery cost, at its steady state

## Fiber Video Transport

Steady-State Distribution Fees
**$110M[3]** per year
*SEE SLIDES 28-34*

÷

Transport Capacity (Gbps)
**40Gbps**
*SEE SLIDES 26-27*

=

Cost per Mbps
**$2.2K**

| | 8Mbps Channel | 25Mbps Channel |
|---|---|---|
| MPEG-4 | **$18K** | **$55K** |

***83% less than Satellite MPEG-4***

***70% less than Satellite HEVC***

## Satellite Video Transport

Steady-State Distribution Fees
**$180M[1,4]** per year

÷

Transport Capacity (Gbps)[2]
**14 Gbps**
*SEE SLIDE 27*

=

Cost per Mbps
**$13K**

| | 8Mbps Channel | 25Mbps Channel |
|---|---|---|
| MPEG-4 | **$105K** | **$325K** |
| HEVC (Future state) | **$60K** | **$195K** |

*It is unlikely that all or most efficiencies gained from higher compression will be passed to programmers*

1. Estimated by assuming a 25% decline in revenue due to removal of 25% of SD feeds over the next 5 years
2. Estimated assuming 25% of MVPD programming transponders use DVB-S Parameters (40MB cap) and 75% use DVB-S2 Parameters (80MB cap)
3. Data Center Costs, Equipment Maintenance, Wavelength Leases, Network Operations Team
4. Transponder Licenses, Equipment Maintenance, Transmission Fees, Personnel

Source: Cartesian, ACA Connects, Intelsat





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# Protecting U.S. Taxpayers

There should be a minimum guarantee payment to the U.S. Treasury from the proceeds of the 5G auction, as well as a ceiling preventing a windfall to incumbents

1. ***Floor ($x billion) for payments to U.S. Treasury***
2. ***Ceiling ($y billion) on incentive payments to incumbents***
3. ***Auction fails if proceeds are not enough to cover Treasury minimum, 130% of estimated costs to MVPDs, programmers and satellite industry, and reserve amount for incumbents***

Source: Cartesian, ACA Connects





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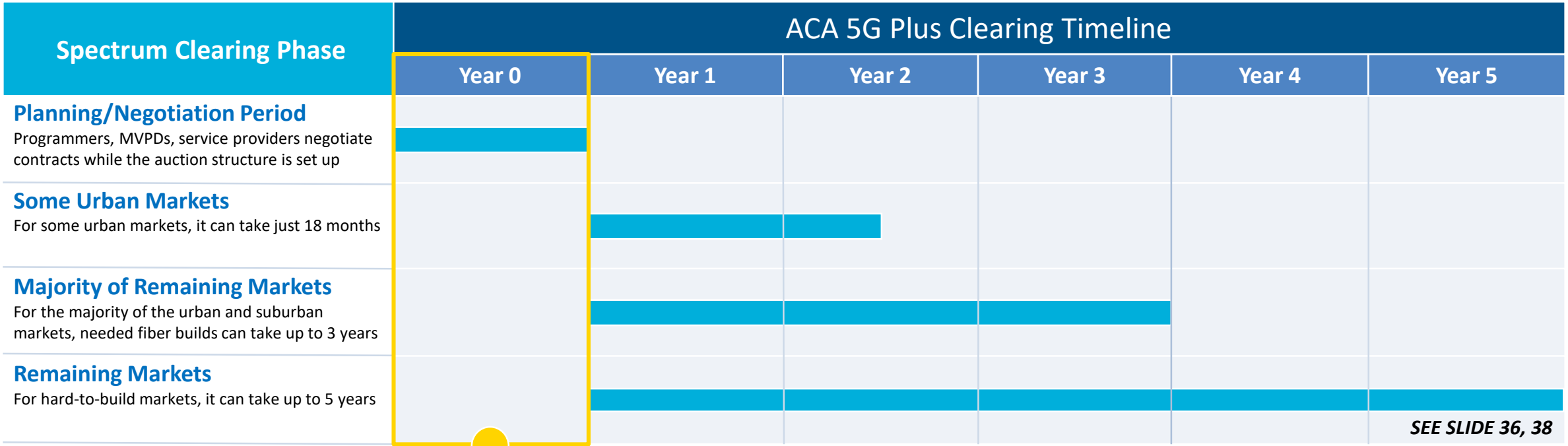
# Clearing Timeline: Summary

Industry stakeholders are able to begin planning and executing service contracts in the period between an FCC decision and the completion of an auction (at least 1 year)




## Year 0 Activities:

**Planning & Contracts**

- MVTPs establish network connectivity
- Programmers and MVPDs work with fiber providers to renew and establish contracts to connect to data centers

*SEE SLIDE 37*

Source: Cartesian, ACA Connects





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# Transition Facilitator Responsibilities

In the past, the Commission has designated an entity to serve as a Transition Facilitator overseeing the clearing of spectrum and reimbursement process

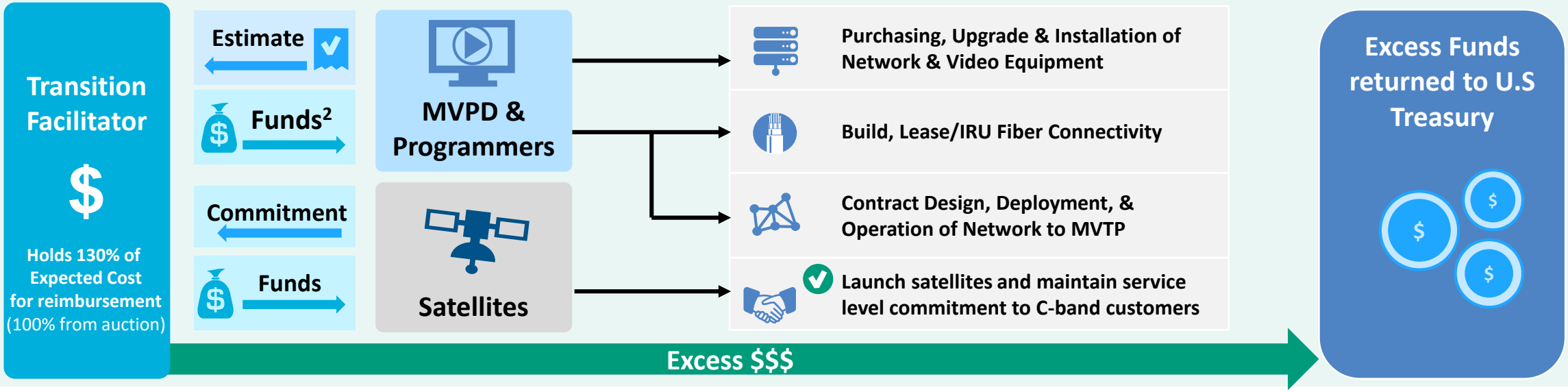
**Primary Roles**

- Collect and Disburse Reimbursement and Incentive Funds
- Provide Approval for 5G Use of C-band in Individual Markets
- Provide Assistance to Stakeholders During Transition Process
- Monitor whether the Satellite Industry Meets its Commitments to Serve C-band Users During and After transition

**Responsibilities left to Parties**

- Select own vendors, equipment, and software, as needed
- Take steps to transition within timeframe

## Reimbursement Model for MVPD Stakeholders and Satellite Industry[1]




1. Not depicted is role of transition facilitator to also reimburse other parties
2. Funds to be administered to MVPDs and Programmers once estimates are delivered to transition facilitator; estimates to be trued up later date

Source: Cartesian, ACA Connects, FCC Docket 18-122





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# Measures to Safeguard C-band Users

The satellite industry will receive both incentive payments and cost reimbursements. To guarantee that satellite operators continue providing superior service to C-band users during and after the transition, incentive payments will be made on a pro rata annual basis over seven years

***Satellite Industry – Incentives & Reimbursements***


***NEW*** →

**Incentive Payment Schedule tied to fulfilled commitments[1]:**

- By disbursing incentive payments on a pro rata annual basis over seven years, the transition facilitator can ensure that the satellite industry meets its obligations

**Reimbursed Costs**

- Reimbursement for new satellite launches to replace satellites reaching end of life
- Reimbursement for repacking of all C-band customers
- Reimbursement in Year 6 and 7 for the two years of lost revenue from the programmers after the MVPD industry completes its transition to fiber in year five

1. ACA Connects C-band Spectrum Clearing Plan, July 8th 2019, slide 13:
"Continue serving non-MVPD earth station operators over the remaining spectrum without price increases for extended period of time"

Source: Cartesian, ACA Connects, FCC Docket 18-122





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# Appendix

# Video Transport Network – Reliability

Based on probability theory, 99.999% or greater reliability can be achieved by 2 independent fiber links; geographic fiber link diversity does satisfy the independency requirement

>= Targeted 5 nines reliability

| | Annual Cuts on Each Fiber Link | Uptime Reliability | |
|---|---|---|---|
| | | Single-Path Architecture | Dual-Path Architecture |
| **Mean Time to Repair ("MTTR") 4 hours** | **1** (Rural) | **3 nines** 99.95% | **6 nines** 99.9999% |
| | **3** (Urban) | **2 nines** 99.86% | **5 nines** 99.9998% |
| **MTTR 8 hours** | **1** (Rural) | **3 nines** 99.91% | **6 nines** 99.9999%[1] |
| | **3** (Urban) | **2 nines** 99.73% | **5 nines** 99.9993% |

## Calculation Assumptions

- Cuts per year on each fiber link varied between 1 and 3
  - **3 fiber outages per year per 1,000 miles in rural areas and 13 in urban areas,** based on FCC reported historical average requirements [1]
  - Between any 2 data centers of the 42 proposed the **maximum distance is about 390 miles** (between Flextential in Salt Lake City and Billings – Central in Montana) and **average distance is about 190 miles**
- The MTTR varies between 4 and 8 hours, the typical SLA for a fiber cut
- Redundant fiber paths are **fully geographically diverse** and not affected by the same fault

## Calculation Formula

- Annual Urban Cuts on Each Link $= \frac{13}{1000}\ x\ 190\ (max.390) = 2.47\ (max.5.07)$
- Annual Rural Cuts on Each Link $= \frac{3}{1000} \times 190\ (max.390) = 0.57\ (max.1.17)$
- Percentage Downtime $= \frac{Cuts\ per\ year \times MTTR}{100}$
- Percentage Uptime Single Path $= 1\ -\ \%\ Downtime$
- Percentage Uptime Dual Path $= 1\ -\ (\%\ Downtime)^2$

Source: Cartesian, CenturyLink, Zayo, [1] FCC 2002: http://www.ece.ualberta.ca/~grover/book/pdf/Intro_n_Outline.pdf





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# C-band Reliability

Based on self reported information, the satellite industry is currently providing between three and four '9s' of reliability

| | | |
|---|---|---|
| **Typical Transponder or Network Fleet Availability** | INTELSAT | 99.997% [1] |
| | SES | 99.999% [2] |
| **Typical Service Availability** | Industry Benchmark | 99.97% [4] |
| | INTELSAT<br>*Quoted C-band service availability per year based on Link Analysis* | 99.96% [3] |
| | SES<br>*Based on Integrated GEO-MEO O3b service targeted at Enterprises* | 99.991% [4] |

## Examples of C-band Satellite Issues

**Satellites are at risk from technical issues, the following examples resulted in adverse effects to C-band service over the past 8 years:**

- SES AMC-9 experienced an undetermined anomaly on 6/17/17, resulting in full retirement[5] and 1-day service downtime[6]
- SES NSS-806 suffered a power anomaly in 2017, resulting in 14 out of 34 C-band transponders being permanently turned off [5]
- Telesat Anik F2 suffered an anomaly on 2/10/16, resulting in 1 day blackout [7] along with another on 6/10/11 [8]
- Intelsat 33e experienced thruster malfunction in 9/1/16, resulting in a 3-month delay in reaching orbit [1]
- Intelsat 19 damaged its south solar array during launch on 6/1/12, resulting in reduced operational capacity [1]
- Intelsat 28 experienced an anomaly in deploying its west antenna in 4/1/11, resulting in full C-band failure [1]

## Signal Jamming Risk

"The threat of satellite signal jamming has increased dramatically... Rogue actors can easily determine with precision which frequencies to jam or monitor in an effort to disrupt active satellite control." - *Eutelsat 2019* [9]

**Improving end-to-end satellite C-band service availability is expensive and requires the use of back-up satellites and/or reserved transponder on capacity on existing satellites**

[1] Intelsat Annual Report 2018. [2] SES Annual Report 2008. [3] Intelsat website: Link Analysis. [4] SES Annual Report 2016. [5] SES Annual Report 2017.
[6] SES 6/27/2017 Press Release. [7] Telesat 10/3/16 Press Release. [8] Telesat 10/6/11 Press Release. [9] Eutelsat Mitigation of Orbital Debris comments to the FCC.
Source: Eutelsat, Intelsat, SES, Telesat





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# Programmer Connectivity

Programmers can select their preferred metro fiber services provider to connect their origination/uplink sites to nearby data centers and handoff their content to a managed video transport provider (MVTP)

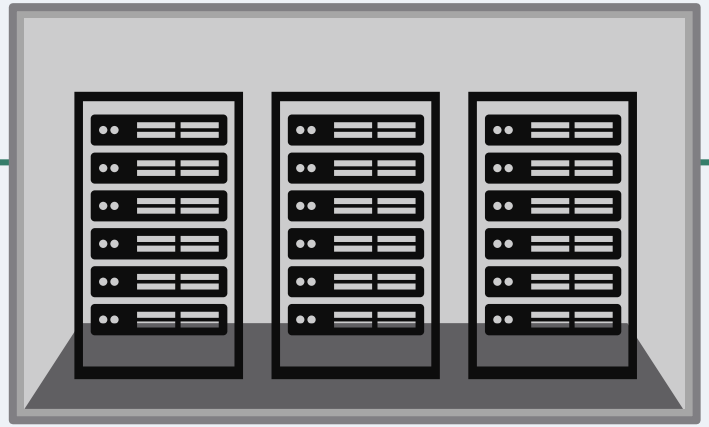
## Programmer Uplink Site to Data Center Connectivity

### Uplink Site

Example Uplink Site Equipment/Software

- User Interface for Programmable Access
- Encoding
- Enterprise CPE
- Encryption

### Data Centers



***Uplink Site to Data Center Connectivity:***

- *Redundant 10G wavelengths*
- *Diverse routes; at least 200 feet, entering data center from east & west*
- *Multiple provider options*

**Programmer Determines How to Obtain Connectivity:**

- Programmers will be reimbursed to obtain connectivity from their uplink sites to handoff points
- Programmers will have funds to choose connectivity vendor, level of redundancy, and data center endpoints
- Labor costs for equipment installation and testing included

**Example Fiber Connectivity Providers:**

AT&T, COMCAST, CROWN CASTLE FIBER, CenturyLink, verizon

**Managed Video Transport Provider Responsibility:**

- The provider will have an incentive to establish a presence in 42 data centers across the country to which programming will be distributed

***See Next Slide for Data Center Details***

Source: Cartesian, ACA Connects





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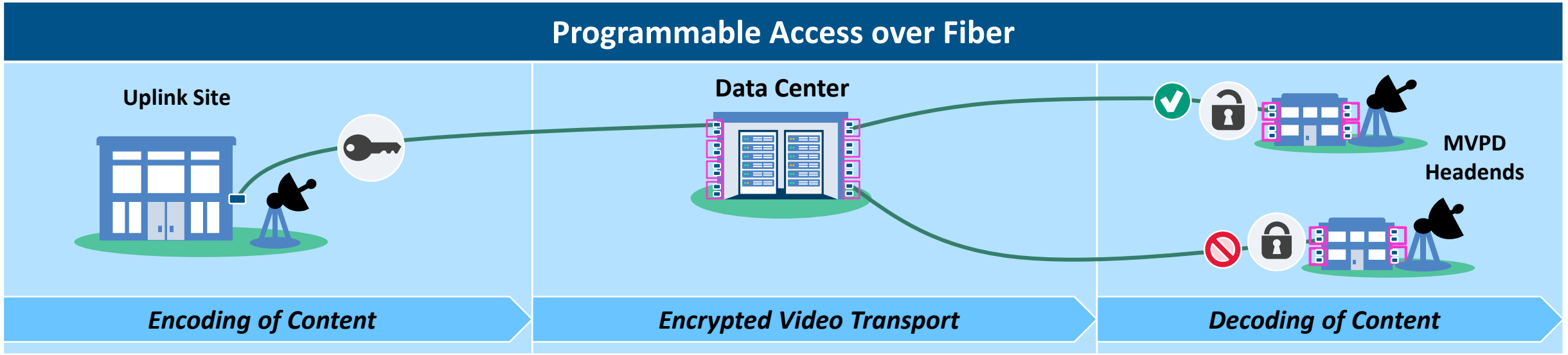
# Video Delivery System – Security & Programmable Access

Programmers can be medium-agnostic and use the same encoding over fiber as they use today over satellite




| | | |
|---|---|---|
| Primary | Encoding | The uplink site will use a device that encodes content – content will be decoded at MVPD headend |
| | Decoding & Programmable Access | • An integrated receiver/decoder (IRD), *which must include a replaceable module encryption strategy to industry standard*, will decode data transmission at the MVPD headend (transition covers cost if MVPDs require new decoders that can handle IP input)<br>• Programmer maintains control over programmable access through an API |
| | Cybersecurity | Firewalls, network management system and probes, threat detection, incident response |
| | Physical Security | Data center equipment can be placed in locked cages |
| Third Party Solutions | Watermarking | **Flexible Solutions**<br>• If programmers require third-party support to transition security solutions from satellite to IP delivery, funds are available to reimburse those costs<br>• If programmers already have compatible solution, *they can continue business as usual and can retain full control (while still being entitled to reimbursement)* |
| | DRM Software | |

Source: Cartesian, ACA Connects

# Video Transport Network – Network Monitoring & Operations Center

A Network Operations Center within each managed video transport provider will be responsible for 24/7 operations of this new private network

## NOC Team/Data Center Support[1]

**Network Engineers:** Remotely monitor network traffic and resolve issues as they arise

**Client Support:** Interface with programmers

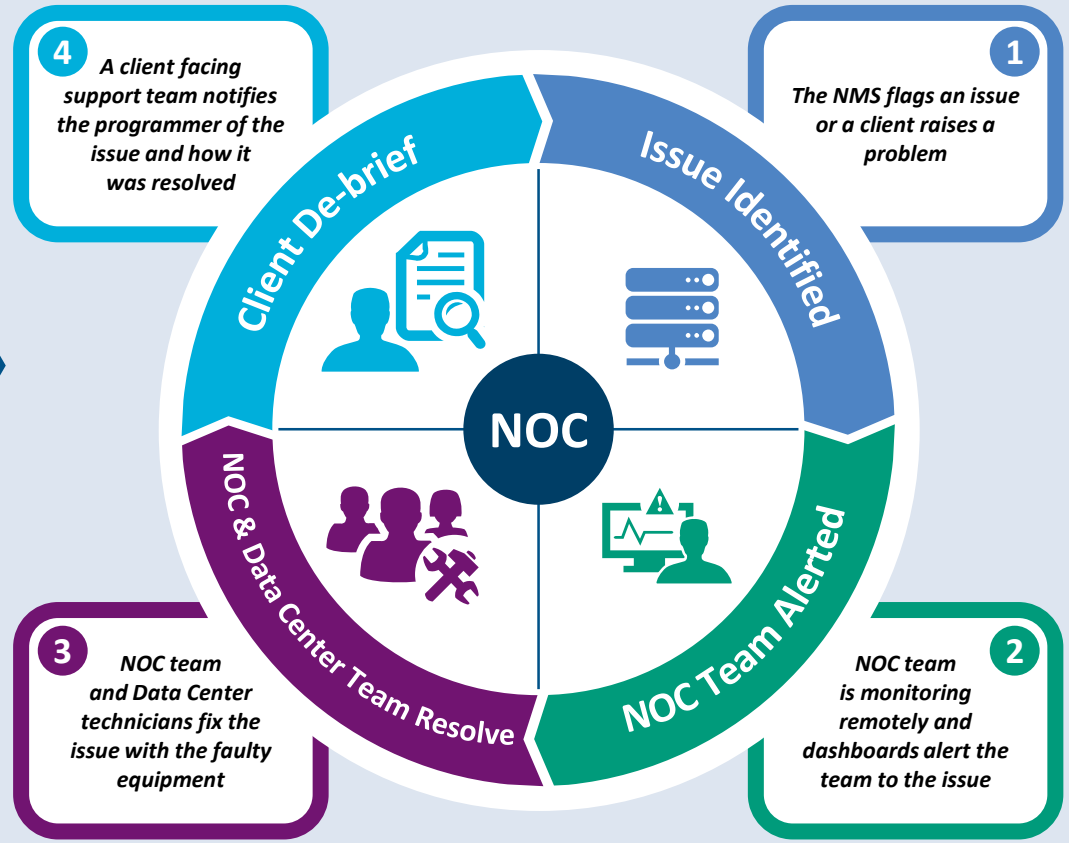
**Data Center Staff:** Onsite IP techs and a video Subject Matter Expert ("SME") at each of the 42 data centers

## Network Management System (NMS)

Video Transport networks will have a comprehensive Network Management System ("NMS") and probes installed to enable:

- **Traffic monitoring**
- **Software monitoring**
- **Hardware monitoring**

## Network Probe Monitoring Process (24/7)




1. Team size determined by revenue for each MVTP and scaled to ensure average revenue per employee is in line with enterprise business units of fiber connectivity and managed service providers

Source: Cartesian, ACA Connects





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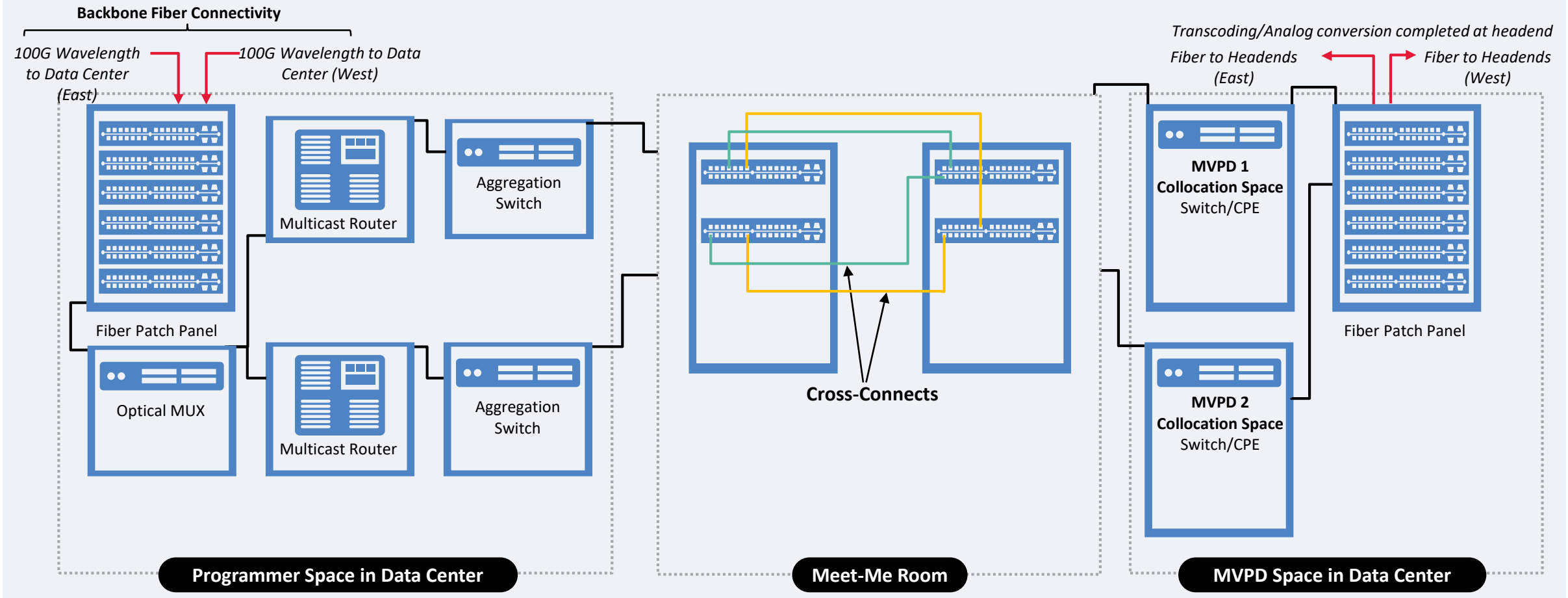
# Video Transport Network – Managed Video Transport Service & MVPD Handoff

MVTPs will deploy redundant optical and routing/switching equipment across the 42 data centers and cross-connect with MVPDs to deliver the programming content

## Illustrative Managed Video Transport Service & MVPD Hand-off Scenario




*NOTE: Programmers and MVPDs may be located in different Data centers*

Cross-Connects | Internal Data Center Cabling | Fiber Entering/Exiting Data Center

Source: Cartesian, ACA Connects





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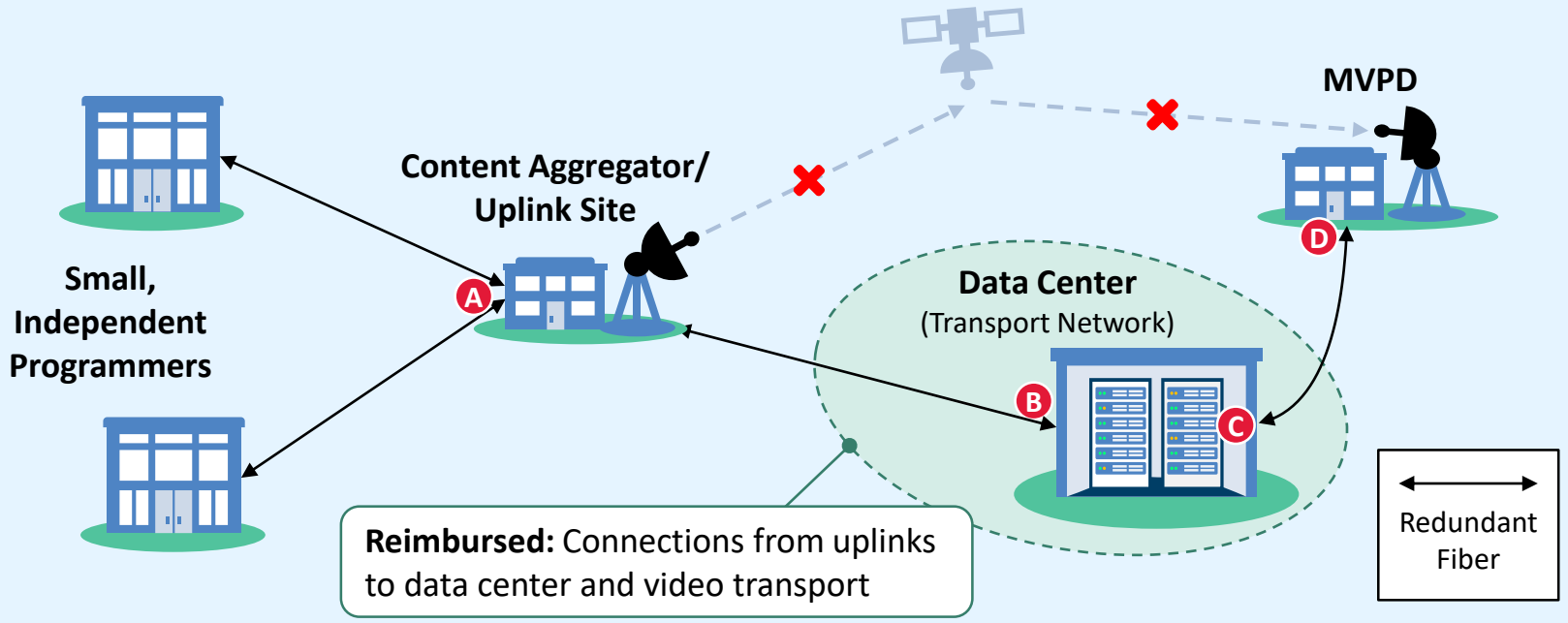
# Independent Programmers

Small, independent programmers using the C-band for MVPD programming who do not own their own uplink sites may use their reimbursement to obtain connectivity from a content aggregator offering a turn-key solution

## Role of Third Parties

ILLUSTRATIVE




## Reimbursements

1. **Eligibility:** All programmers who currently use C-band to transport MVPD programming are eligible for reimbursement
2. **Reimbursement:** Eligible programmers receive reimbursement for cost to connect from location of their current uplink sites to data centers and for national fiber video transport services
3. **Third Parties:** Programmers may outsource connectivity and transport management to a third-party aggregator or keep management of network in-house

**Content Aggregators:** arqiva, ENCOMPASS, VUBIQUITY, GLOBECAST

- **A** Take feeds/files from programmers and package content for consumption
- **B** Manage the handoff between small programmer and MVTP
- **C** Collocate for small MVPDs in data center and aggregate all programming content
- **D** Manage the handoff with MVTP and delivery of content to the MVPD headend

Sources: Cartesian, Communication Provider websites





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# Updated Bandwidth Assumptions

A 40G fiber core is sufficient for all current & near-future needs

## Bandwidth Estimates

### Future State

| | | | | | | |
|---|---|---|---|---|---|---|
| UHD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 200 | | 35 Mbps | | 7 Gbps | | |
| HD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 500 | | 25 Mbps | | 12.5 Gbps | | |
| SD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 1,200 | | 10 Mbps | | 12 Gbps | | |
| Blackout Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 100 | | 25 Mbps | | 2.5 Gbps | | |
| VOD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 100 | | 25 Mbps | | 2.5 Gbps | | |

**Total Bandwidth**

**36.5 Gbps**

### Current State

| | | | | | | |
|---|---|---|---|---|---|---|
| UHD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 0 | | 35 Mbps | | 0 Gbps | | |
| HD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 500 | | 25 Mbps | | 12.5 Gbps | | |
| SD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 1,200 | | 10 Mbps | | 12 Gbps | | |
| Blackout Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 100 | | 25 Mbps | | 2.5 Gbps | | |
| VOD Channels | X | Bandwidth/Channel | = | Bandwidth | | |
| 100 | | 25 Mbps | | 2.5 Gbps | | |

**Total Bandwidth**

**29.5 Gbps**

## Comments and Implications

- **100G Backbone Link:** Reimbursable cost accounts for each MVTP to provide redundant 100G links to ensure the network:
  1. Has capacity to transport future high-quality content (i.e., 200 UHD Channels)
  2. Can accommodate bandwidth of numerous blackout channels
  3. Can transport the highest-quality, uncompressed streams provided by programmers
- **MVPD Handoff:** Not all MVPDs will offer the entirety of available content and are expected to:
  1. Compression content to reduce bandwidth
  2. Buildout or IRU fiber to connect to data center endpoints
- **Blackout Channels:** Estimate includes only local blackout channels to account for reusable bandwidth between markets

Source: Cartesian, MVPD Operator Interviews, SNL Kagan, Programmer Interviews





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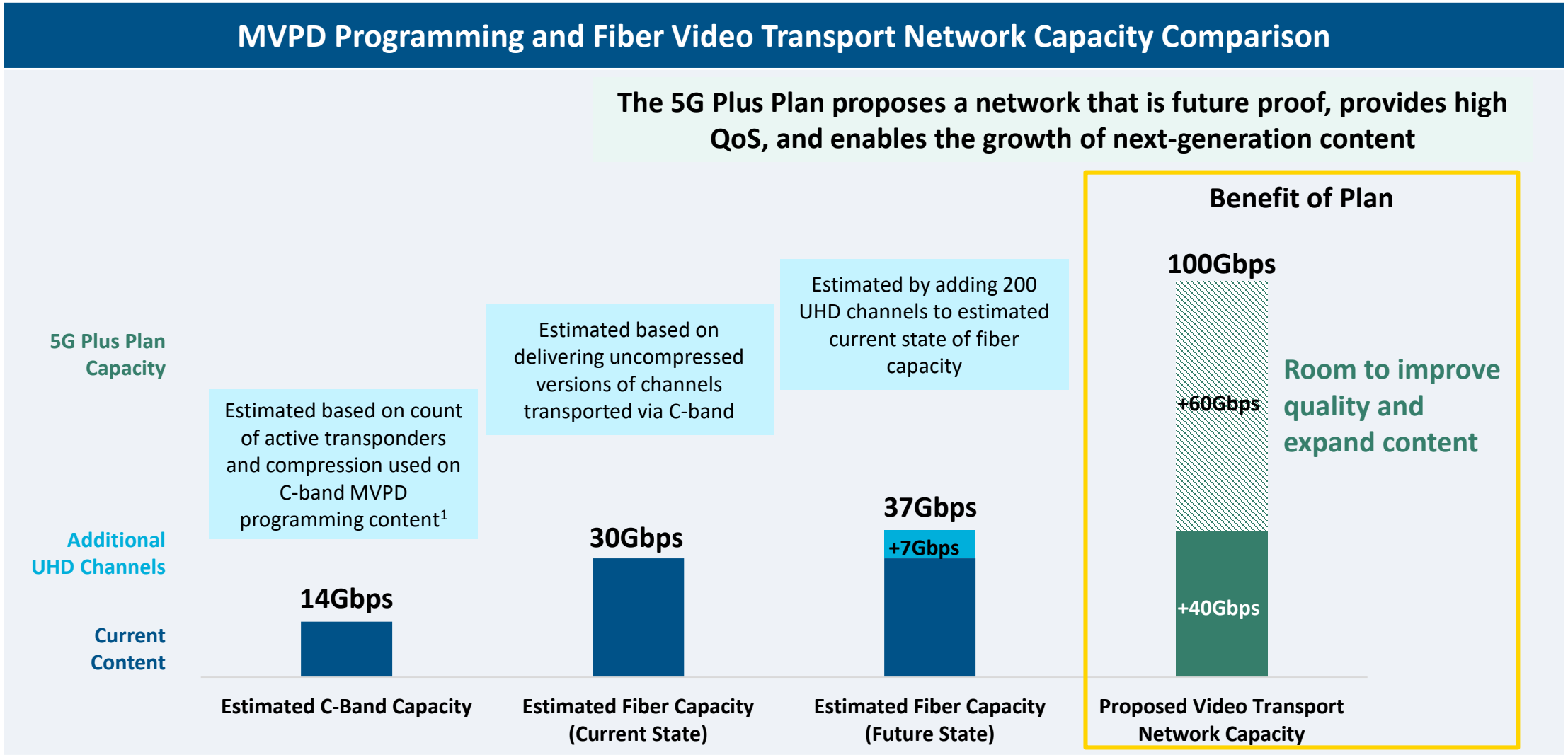
# Future-proof Capacity

A 100G fiber network core capacity makes the fiber networks entirely future-proof




1. Estimated by assuming 25% of MVPD programming transponders use DVB-S Parameters (40Mbps capacity) and 75% use DVB-S2 Parameters (80Mbps capacity)

Source: Cartesian, MVPD Operator and Programmer Interviews, Lyngsat





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# Increase in Reimbursable Cost to Programming Industry

By incorporating programmers' requirements on reliability and solution feature requirements, we have refined and increased programmers' reimbursable costs to be approximately $1B

***Total 5-Year Reimbursement to Programming Industry of 5G Plus Plan*** *(4 Service Providers)*

| Type | Item | Total Cost |
|---|---|---|
| CAPEX | Equipment (Initial Investment & Replacement) | $305M |
| | Network Operations Center (NOC) | $40M |
| OPEX | Security and Programmable Access | $100M |
| | Hardware Maintenance | $120M |
| | Increase in Backbone Capacity | $38M |
| | Network Operations Centers Staffing | $190M |
| MARGIN | Solution Provider Margin | $160M |
| **Total Increase in 5-Year Reimbursement to Programming Industry** | | **$1B** About 8% above original total estimate |

Source: Cartesian, ACA Connects





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# Video Transport Network – 5-Year Cost Estimate

The required amount for 4 providers to build out and operate over 5 years an end-to-end fully managed video distribution service is approximately $1B

| Requirement | Description | Expenditure | |
|---|---|---|---|
| | | Capital | 5 Year Opex |
| **Hardware Costs** | • **Equipment required to make 42 data centers and 80 uplink centers operational**<br>› Full redundancy accounted for in all equipment housed at data centers and uplink stations and wavelength connections | **$185M** | N/A |
| **IRD and Encoders** | • **Paying to transition encoders at the uplink sites and IRDs at the MVPD/head-ends**<br>› Allocating funds to replace components that aren't IP compatible | **$100M** | N/A |
| **Maintenance Expenditure** | • **Maintenance operating expenditure is estimated at 15% of capital expenditure per year**<br>› Industry averages of 15% were used to estimate operational expenditure | N/A | **$120M** |
| **Replacement Expenditure** | • **Replacement capital expenditure was included in the 5 year reimbursement period**<br>› Industry averages of 10% were used to estimate replacement capital expenditure | **$20M** | N/A |
| **Wavelength Leases And Collocation** | • **Geographically diverse redundant Wavelength leases connecting all data and uplink centers**<br>• **Collocation costs for rented space at each of the data centers** | N/A | **$110M** |
| **Security** | • **Maintain an end-to-end cybersecurity solution**<br>› Firewalls, Network Management System and probes, threat detection, incident response | N/A | **$100M** |
| **NOC Staffing** | • **NOC team**<br>› A team of 340 engineers, technicians and client support providing back end maintenance, problem resolution and support across all four providers | N/A | **$190M** |
| **Solution Margin** | • **A managed service margin was applied to annual cost**<br>› Industry average of 30% for managed services operating units | **$20M** | **$140M** |
| **Total Reimbursable 5-Year Cost to Programmers** | | **$325M** | **$655M** |

Source: Cartesian, ACA Connects





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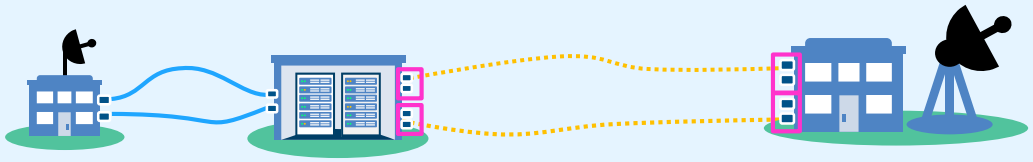
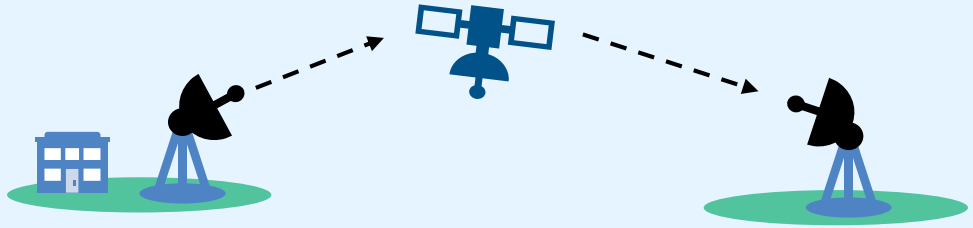
# Future State Comparison: Fiber vs. Satellite Costs; You Pay Less to Get More

In a steady state, programmers should expect savings of 40% by transitioning video delivery from satellite to fiber

| Fiber Transport | Satellite Transport |
|---|---|
|  |  |
| **Fiber Video Distribution Costs**<br>• Data Center Costs<br>• Equipment Maintenance<br>• Wavelength Leases<br>• Network Operations Team | **Satellite Video Distribution Costs**<br>• Transponder Licenses<br>• Equipment Maintenance<br>• Transmission Fees<br>• Personnel |
| Annual Steady-State Video Transport Cost<br>**$110M/Year** | Annual Steady-State Video Transport Cost<br>**$180M/Year[1]** |

**After Year 6, programmers could save about $70M annually on video transport costs**

1. Estimated by assuming a 25% decline in revenue due to removal of 25% of SD feeds over the next 5 years

Note: Steady-State Fiber Video Delivery Cost calculation is derived from years 2 – 5 excluding Capital expenditure required in year 1

Source: Cartesian, ACA Connects





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# Video Transport Network – Steady State

Following year 1 capital expenditure, average operating expenditure for four video transport providers and origination connection is $110M per year

| Operational Expense | Description | Video Transport Provider | Origination Site |
|---|---|---|---|
| **Uplink Station Wavelength Cost** | • **80 Uplink Stations**<br>› Annual cost for 10G fully redundant wavelengths connecting 80 uplink stations | N/A | **$10M** |
| **Data Center Wavelength Cost** | • **42 Data Centers**<br>› Annual cost for 100G fully redundant wavelengths connecting 42 data centers | **$13M** | N/A |
| **Hardware Maintenance** | • **Average annual charge for 15% of total CapEx**<br>• **Average annual charge for 10% replacement CapEx Year 5** | **$30M** | N/A |
| **Collocation costs, Rackspace, Cross-connects** | • **Average rental charge per year within data centers** | **$7M** | N/A |
| **Staff** | • **Engineers** (130)<br>• **Client Support** (43)<br>• **Data Center Techs** (168) | **$50M** | N/A |
| **Cost** | Average Annual Operating Expenditure for Programmers: **$110M** | | |

**Note: Margin for service provider is included in each line item**
Source: Cartesian, ACA Connects





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# Requirements – Capex for One Service Provider

The cost model includes upfront capex on equipment and hardware required to set up a video transport network for one MVTP – redundant equipment is included in the total cost incurred by MVTP

| Requirement | Description | Unit Cost | Total Cost |
|---|---|---|---|
| Optical Multiplexors | ▶ One multiplexor for primary and redundant links across all 42 data centers | $200K | **$16.8M** |
| Multicast Routers | ▶ One router for primary and redundant links across all 42 data centers | $100K | **$8.4M** |
| Short Range SFPs | ▶ Two SFPs for 1) primary and redundant links across all 42 data centers, and 2) cross-connect with 2.5K MVPD cable systems | $4K | **$10.3M** |
| Aggregation Switches | ▶ Two 40-port aggregation Layer 2/3 switches for each primary and redundant link across all 42 data centers – assumed service providers will scale aggregation switches based on the number of clients per site | $10K | **$672K** |
| Network Probes | ▶ Full monitoring equipment at 10% of sites, sample monitoring at remainder of sites and all endpoints<br>▶ Cybersecurity monitoring spanning full video transport network | $N/A | **$8M** |
| NOC Buildout | ▶ Upfront cost of building and deploying software for a network operations team to monitor the network 24/7 | $N/A | **$2M** |
| **TOTAL ESTIMATED CAPEX FOR ONE PROVIDER** | | | **$46M** |

Source: Cartesian





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# Requirements – Capex for Equipment Managed by Programmers

The cost model includes a significant amount of upfront capex on equipment and hardware enabling programmers to update all equipment they currently manage

| Requirement | Description | Unit Cost | Total Cost |
|---|---|---|---|
| Encoders | ▶ Replacement encoders for non-IP compatible encoders<br>▶ Allocated cost for five encoders per programmer | $10K | **$30M** |
| Network Interface Device | ▶ Enterprise-grade CPE/Ethernet switch with SFP slots, and encryption devices for each link at 80 uplink sites | $100K | **$16M** |
| Integrated Received/Decoder (IRD) | ▶ Integrated Received/Decoder for each primary and redundant links – must include a replaceable module encryption strategy to industry standard | $1K | **$80M** |
| **TOTAL ESTIMATED CAPEX FOR EQUIPMENT MANAGED BY PROGRAMMERS** | | | **$126M** |

Source: Cartesian





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# Requirements – Opex for Four Service Providers

Average steady state operating expenditure for four video transport providers is $110M per year and excludes services not currently provided by satellite providers today

| Requirement | Description | Total Cost |
|---|---|---|
| Uplink Station Wavelength Cost | ▶ **80 Uplink Stations**<br>› Annual cost for 10G fully redundant wavelengths connecting 80 uplink stations | $8M |
| Colocation costs, Rackspace, Cross-connects | ▶ **Average rental charge per year within data centers** | $7M |
| Hardware Maintenance | ▶ **Operation Expenditure estimated at 15% of initial Capex Spend** | $30M |
| Data Center Wavelength Cost | ▶ **42 Data Centers**<br>› Annual cost for 100G fully redundant wavelengths connecting 42 uplink stations | $13M |
| Staffing | ▶ **340 Staff salaries (All four)**<br>› Staff is comprised of engineers, client support, and data center technicians | $50M |
| **AVERAGE ANNUAL OPEX FOR CORE TRANSPORT SERVICES** (COMPARABLE TO SATELLITE) | | $110M |

| | | |
|---|---|---|
| Cybersecurity | ▶ **Enables the secure transmission of content via fiber and control over programmable access through an Application Programming Interface** | $25M |
| IRD Maintenance | ▶ **Estimated replacement and maintenance on IRD** | $10M |
| **AVERAGE ANNUAL OPEX FOR SERVICES NOT INCLUDED IN SATELLITE TRANSPORT COST** | | $35M |

Source: Cartesian





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# Data Center Locations

To minimize the distance to all MVPD headends, the network will connect to data centers in these 42 cities.

| Count | City | State |
|---|---|---|
| 1 | Charlotte | NC |
| 2 | Houston | TX |
| 3 | Fairview | OR |
| 4 | Pittsburgh | PA |
| 5 | Manassas | VA |
| 6 | San Antonio | TX |
| 7 | College Park | GA |
| 8 | Cleveland | OH |
| 9 | Philadelphia | PA |
| 10 | Minnetonka | MN |
| 11 | Englewood | CO |
| 12 | Independence | MO |
| 13 | Saint Louis | MO |
| 14 | Troy | MI |

| Count | City | State |
|---|---|---|
| 15 | Florence | KY |
| 16 | Oak Forest | IL |
| 17 | San Francisco | CA |
| 18 | Bellevue | WA |
| 19 | Dallas | TX |
| 20 | Boston | MA |
| 21 | Orlando | FL |
| 22 | Sioux Falls | SD |
| 23 | Liberty Lake | WA |
| 24 | Albuquerque | NM |
| 25 | Oklahoma City | OK |
| 26 | Nashville | TN |
| 27 | Wilkes Barre | PA |
| 28 | Tampa | FL |

| Count | City | State |
|---|---|---|
| 29 | New York | NY |
| 30 | Gilbert | AZ |
| 31 | Fort Lauderdale | FL |
| 32 | Chatsworth | CA |
| 33 | Annapolis | MD |
| 34 | Boise | ID |
| 35 | New Orleans | LA |
| 36 | Memphis | TN |
| 37 | El Paso | TX |
| 38 | Salt Lake City | UT |
| 39 | Des Moines | IA |
| 40 | Las Vegas | NV |
| 41 | Billings | MT |
| 42 | Bemidji | MN |

Source: Cartesian, Datacenter Maps





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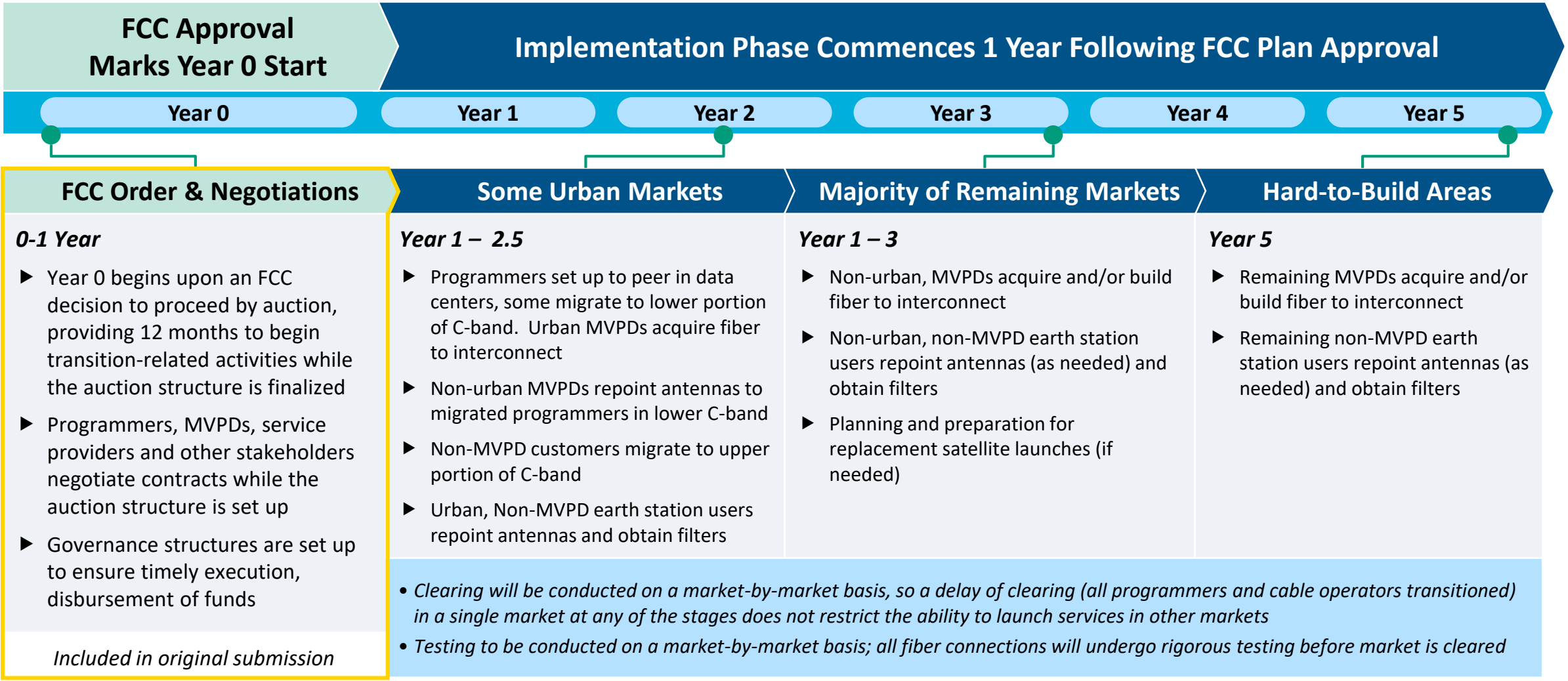
# Timeline Targets

Industry stakeholders will be able to begin planning and executing service contracts in the period (at least 1 year) between an FCC decision and the completion of spectrum auctions




Source: Cartesian, ACA Connects

# Year 0 Activities

**Yr. 0:** FCC Approval & Negotiations → Some Urban Markets → Majority of Remaining Markets → Hard-to-Build Areas

| Activity | Description |
|---|---|
| **Planning** | **Uplink Site Connectivity:** Programmers will work with fiber providers to increase connectivity and reliability to the video transport network<br>**MVPD – Data Center Connectivity:** MVPDs will plan to establish fiber connectivity from MVPD headends to one of the 42 data centers that will serve as a video delivery endpoint<br>**Network Design:** Service providers will begin designing the video transport network solution to programmer specifications (e.g., redundant, geographically diverse) and develop a workplan |
| **Contracts** | **Technical Specifications:** Programmers will work with multiple service providers to define the requirements (e.g., SLAs, content security) of the video transport network<br>**MVPD Contracts:** Programmers will work with MVPDs to update the delivery end points as the 42 data centers on the video transport network and develop a plan to quick transition once the auction occurs |
| **Upper Band Repacking** | **Transponder Identification:** Programmers will work with satellite operators to identify the transponders that will need be repacked within the lower 370 MHz of the C-band<br>**Launch Preparation:** Satellite operators can prepare to launch additional satellites to meet future capacity demands if necessary |

Source: Cartesian, ACA Connects





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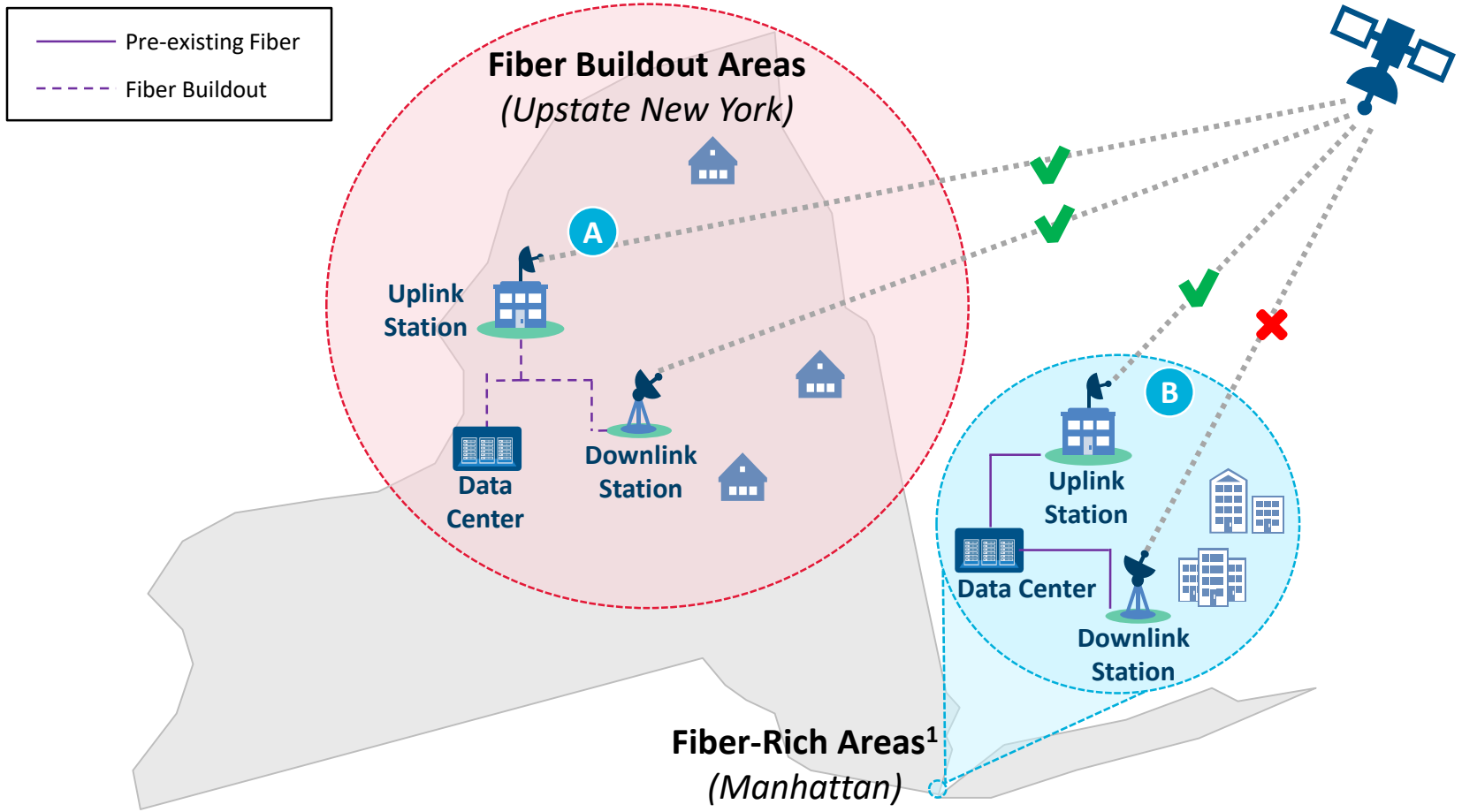
# Market Transitioning

Satellites will remain operational for at least 5 years to ensure that service can be provided to “hard-to-reach” markets throughout the transition period

## Example PEA

ILLUSTRATIVE




**A Fiber Buildout Areas (e.g., Upstate NY Counties)**

- Uplinks and satellites continue to transmit for 5 years
- Downlinks remain operational where the FCC finds that fiber deployment has not yet met requirements

**B Fiber-Rich Counties (e.g., New York County)**

- Uplinks and satellites continue to transmit for 5 years
- Downlinks decommissioned to enable refarming of spectrum for 5G services

1. Circle is intended to represent Manhattan and has been enlarge for visual purposes
Source: Cartesian, ACA Connects, FCC Docket 18-122





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BOSTON

KANSAS CITY

LONDON

NEW YORK

PARIS